Metabolic cost of swimming in killer whales, with implications for estimating daily energetic requirements

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Summary

1. Energy expenditure and consumption are critical components of animal ecology. Maintaining a balance between these two factors is vital for survival. Data on both elements are required to assess this balance, but there is a paucity of data on energy expenditure for large, free-ranging vertebrates, such as cetaceans.

2. Obtaining estimates of field metabolic rates with doubly labelled water and other techniques may be unfeasible for large free-living vertebrates due to logistical constraints.

3. Oxygen consumption measurements from captive animals have provided useful data on resting metabolic costs and activity-specific energy expenditure for some species. However, a combination of oxygen consumption data from captive subjects and behavioural data from free-ranging subjects may provide reliable estimates of total daily energetic requirements for wild cetaceans.

4. Data on swimming speeds and respiration rates from free-swimming adult "northern resident" killer whales (*Orcinus orca*) were used in combination with published values of oxygen consumption from captive whales to estimate energetic cost of transport (COT) over the range of speeds observed in wild adults.

5. For both males and females, respiration rate (breaths min^{-1}) was positively correlated with swimming speed (m s^{-1}), while breaths km^{-1} decreased with swimming speed, according to a power function.

6. Our estimates for minimum COT were similar to those predicted by a published allometric equation for COT in marine mammals. This confirmation supports the use of these methods for estimating energy expenditure over the range of swimming speeds observed during our study. COT (J m^{-1} kg^{-1}) decreased with swimming speed according to a power function. However the COT for females at any given speed was greater than that for males. Females travelling with young calves appeared to have a greater COT than those without calves.

7. Minimum COT values for swimming killer whales corresponded to speeds of 2.6 to 3.0 m s^{-1} and are considered optimal swimming speeds for these animals. Although optimal swimming speeds enable animals to travel over long distances most efficiently, total daily energy expenditure is actually lower when killer whales swim at somewhat slower speeds, such as the observed average travel/forage speed of 1.6 m s^{-1}. Future research should explore trade-offs between swim speeds that are optimal for long-distance travel and those that are optimal for prey detection and capture.